CONCRETE BATCH PLANT SUPERVISOR

Concrete is a mixture of cement and water that binds aggregates, such as sand and gravel or crushed stone, into a rockdikc mass and when properly constructed, it is very rigid and has a long life. This is a result of the chemical reaction between the cement and water called *hydration*. The Naval Construction Force (NCF) has various equipment used to provide concrete for construction purposes. This equipment ranges from the 11S mixer, transit mixer, mobile concrete mixer plant (crete mobile), and the concrete batch plant.

Most concrete production operations are supported by an experienced Builder (BU). However, EOs must understand the basic principles of concrete mix design and the procedures performed to produce quality concrete.

CONCRETE BATCH PLANT SUPERVISOR RESPONSIBILITIES

When assigned as the supervisor of a concrete batch plant in the NCF, you supervise the production and transport of concrete products used to construct sidewalks, roads, footers, foundations, walls, roofs, runways, rapid runway repairs, and so forth.

PORRLAND CEMENT

Portland cement is usually made of materials, such as limestone or marl and shale or clay. The raw materials are crushed, pulverized, and mixed in proper proportions for the correct chemical composition. Then, the raw material is fed into a rotary kiln and is calcined (burned) at a temperature of approximately 2700°F. This process transforms the material into a clinker. The clinker is cooled and pulverized so fine that nearly all of the powder can pass through a No. 200 mesh sieve.

Types of Cement

When powdered Portland cement and water are combined, hydration occurs, The amount of water per unit weight of cement is called the water-cement ratio normally given in terms of pounds of water per pounds of cement. Concrete with a low water cement ratio gains more strength than cement with a higher water cement ratio.

There are many types of cement, but only the most common types are listed here:

Type I (normal portland cement) is the most widely used cement for pavements, sidewalks, buildings, bridges, masonry units, and soil-cement mixtures. In general, it is used when the concrete will not be subjected to special sulfate hazards or where the heat generated by the hydration of the cement does not cause an objectionable rise in temperature.

Type II (modified portland cement) has a lower heat of hydration than Type I. This lower heat gives this cement an improved resistance to sulfate attack. Type II cement is used in large structures where cement of moderate heat of hydration tends to minimize a rise in temperature. Examples are as follows: large piers, heavy abutments, heavy retaining walls, and when the concrete is placed in warm weather. Type 11 cement is also used in drainage structures where the sulfate concentrations are higher than normal.

Type III (high-early-strength portland cement) is used when superior strength is required in a short time. It is used in cold-weather construction to reduce the period of protection against low temperatures. Type III is also used when forms have to be removed immediately to allow the concrete to be put in service as quickly as possible. Type III cement requires less protection time from freezing and attains normal 3-day strength in 1 day. The volume of heat during hydration is also accelerated. Normally, this cement is not used in large-scale construction operations because it is very expensive.

Storage of Cement

Portland cement is a moisture-sensitive material that must be protected from damp air or moisture. Cement not protected when in storage sets more slowly because hydration has already begun; therefore, it has less strength than portland cement that is kept dry.

Most types of portland cement are shipped in bulk by rail, truck, or barge. Pneumatic loading and unloading of the transport vehicles is the usual method used to handle bulk cement. Bulk cement is measured in tons (2,000 lb) and smaller quantities are bagged in cloth or paper sacks, each containing 94 pounds of cement. A 94-pound sack of cement is equal to 1 cubic foot by loose volume.

Cement bags should not be stored on damp floors, but should rest on pallets. The bags should be stacked against each other to prevent circulation of air between them, but not stacked against outside walls. If the stacks of cement are to be stored undisturbed for long periods, they should be covered with tarpaulins.

Cement bags that have been stacked in storage for long periods sometimes acquire a hardness called *WAREHOUSEPACK.* This can usually be loosened by rolling the sack around. Cement that has lumps or is not free flowing should not be used.

AGGREGATE

The aggregates used in concrete must be strong, durable, and chemically inert and generally occupy 60 to 75 percent of the concrete mix in volumc (70 to 85 percent by weight). Natural aggregate deposits are excavated from pits, rivers, lakes, or seabeds. These natural deposits consist of gravel and sand that can be readily used in concrete after minimal processing. Crushed aggregates are produced by crushing quary rock, boulders, cobbles, or large-size gravel. Crushed aggregates are usually washed and graded before being used in concrete. The most commonly used aggregates are sand and gravel and when combined with cement produce a strong, durable mass that is practically without voids.

The coarse aggregates used in a mix usually consist of gravel or crushed stone up to 1 1/2 inches in size. Course aggregates are primarily used as filler. These aggregates can pass through a 3-inch sieve and are retained on a No. 4 sieve. In massive structures like dams, the coarse aggregates may include natural stones or rocks, ranging up to 6 inches or more in size.

Fine aggregates are those materials that can pass through a No. 4 sieve but are retained on a No. 100 sieve. The fine aggregates and sand in concrete are used to fill the voids between the large aggregates. Care should be taken to prevent dirt and othcr debris from getting mixed into the sand. The foreign material affects the bonding quality of the sand.

The gradation of the aggregate is a major factor in the workability, water requirements, and strength of concrete. Fine and coarse aggregates are usually sieved separately-the fine aggregates on sieves with openings 1/4 inch or smaller and the coarse aggregate on sieves with square openings from about 1/4 inch and larger. The fine sieves are numbered—the larger the number, the smaller the sieve opening; for instance, the No. 100 sieve has 100 openings per inch, and the No. 4 sieve has 4 openings per inch.

The grading of both coarse and fine aggregate and the relative proportions of each in the mix can greatly affect the properties of the fresh concrete. Concrete made with coarse sand or not enough sand is hard to pump and will be harsh and difficult to trowel. Also, aggregates can segregate or separate from the cement paste during placement, producing nonuniform concrete. Air-entraining will help in overcoming grading problems of this kind. Coarse aggregates should be round or subround in shape. This thape allows the cement paste to coat the particles more easily during mixing.

HANDLING AND STORAGE OF AGGREGATES

Aggregates containing particles of different sizes have a natural tendency to segregate whenever loaded, transported, or otherwise disturbed. Aggregates should always be handled and stored by a method that minimizes segregation.

Stockpiles should not be built up in cone shapes, formed by dropping successive loads at the same spot. This process causes larger aggregate particles to segregate and roll down the sides, leaving the pile with a large amount of fine aggregate at the top and a large amount of coarse aggregate at the bottom. A stockpile should be built up in layers, each made by dumping successive loads alongside each other.

If aggregate is dropped in a free fall from a clamshell, loader, or a conveyor, some of the fine material may be blown aside, causing segregation of fines on the lee side of the pile. Clamshells, loaders, and conveyors should be discharged in contact with the pile.

The bottom of an overhead charging bin should always slope at least 50 degrees towards the center outlet. If the slope is less than 50 degrees, segregation will occur as the material is discharged. When a bin is being charged, the material should be dropped from a point directly over the outlet. Material dropped in at an angle or discharged against the sides of the bin will segregate. Since a long drop causes both segregation and the breakage of aggregate particles, the length of a drop into a bin should be kept to a minimum by keeping the bin as full as possible at all times.

WATER

The primary function of water used in a concrete mix is to start the hardening process of the concrete through hydration of the cement. A secondary function is to make the mix workable enough to satisfy the requirements of the job. However, too much water will cause a loss of strength by upsetting the water-cement ratio. It will also cause "water gain" on the surface, a condition which leaves a surface layer of weak material called LAITANCE. Also, an excessive amount of water will impair the water tightness of the concrete.

Water used in mixing concrete must be clean and free from oils, alkalis, acids, and organic materials. Most specifications recommend the mixing water be fit for drinking. This is because any water fit for drinking is usually satisfactory for use in mixing concrete. Seawater may be used for unreinforced concrete.

ADDITIVES USED IN CONCRETE

There are several additives or admixtures used to change the composition of concrete or to accelerate or retard its hardening. The three commonly used are air-entraining agents, retarders, and accelerators. Additives are not recommended if the end result can be reached more economically by altering the mix proportions.

Air-entraining portland cement is a special cement that can be used with good results for a variety of conditions. It was developed to produce concrete that has a resistance to freeze-thaw action and scaling caused by chemicals applied for severe frost and ice removal, Air-entraining agents are liquids derived from natural wood resins, animal fats, vegetable fats, or various wetting agents, such as alkali salts and water-soluble soaps. Agents are blended with the cement during manufacturing or added at the mixing site. If done at the site, the agent is added to the water used in the mix.

Manufactured air-entraining cements are indicated by the letter *A* in the type number (Types IA, IIA, IIIA, etc.). Concrete made with this cement contains billions of extremely small, entirely separated air bubbles per cubic foot of concrete. These bubbles provide space for water to expand due to freezing without damage to the concrete.

Retarders are used to slow down the rate of setting of a concrete. High temperatures of fresh concrete (85°F - 90°F and higher) are often the cause of an increased rate of hardening that makes placing and finishing difficult. One practical way to reduce the temperature of the concrete is by cooling the mixing water or the aggregates. Retarders do not decrease the initial temperature of the concrete. Retarders are sometimes used (o do the following:

1. Offset the accelerating effect of hot weather on the setting of concrete
2. Delay the initial set of concrete when difficult or unusual conditions of placement occur, such as placing concrete in large piers and foundations
3. Delay the set for a special finishing process, such as an exposed aggregate surface

Some of the materials used to retard the set of a concrete mixture are lignin, borax, sugar, tartaric acid, and salt. These materials should be added to the mixing water.

CAUTION

If 20 percent by volume of regarding agent is added to the mix, the effect is reversed and it then acts as an accelerator.

Accelerators are used to accelerate the strength development of concrete at an early age. Calcium chloride is the material most commonly used in accelerating admixtures; however, in addition to accelerating strength gain, calcium chloride causes an increase in drying shrinkage, potential reinforcement corrosion, discoloration, and scaling potential. Calcium chloride should be added to the concrete mix in solution form as part of the mixing water. If added to the concrete in dry form, all of the dry particles may not be completely dissolved during mixing. Undissolved lumps in the mix can cause pop-outs of dark spots in the hardened concrete. The amount of accelerator used should not exceed 2 percent by weight of cement.

COMPUTING CONCRETE VOLUME

To compute the volume of concrete required for a concrete pad, multiply the length of the pad by its width times its depth to get cubic feet (L x W x D); for example, a concrete pad is 20 feet in length by 30 feet in width and has a depth of 3 inches. First, convert the 3 inches into feet by dividing 3 by 12 to get 0.25 foot. Next, multiply the 20-foot length by the 30-foot width to get 600. Finally, multiply the 600 by 0.25 to determine the volume of concrete required for the pad which, in this case, is 150 cubic feet.

Concrete is ordered and produced in quantities of cubic yards. To calculate the number of cubic yards required for the pad, divide the cubic feet of the pad by 27. This is required because there is 27 cubic feet in 1 cubic yard. Therefore, the concrete pad described in the previous paragraph, which has a volume of 150 cubic feet, requires 5.56 cubic yards of concrete: 150 cubic feet divided by 27 = 5.56 cubic yards.

Concrete projects often present varying degrees of difficulty; therefore, extra concrete is required to compensate for these difficulties. Once the total number of cubic yards of concrete is computed, add a little extra, normally 10 percent, to compensate for waste. To calculate the excess needed, multiply the cubic yards by .10 (10 percent). In the above case, multiply 5.56 cubic yards by .10 to get 0.556 cubic yards. Add the 0.556 cubic yards to the 5.56 cubic yards for a total of 6.116 or 6.12 cubic yards required for the concrete pad.

BATCHING CONCRETE

Batching is the process of weighing or volumetricall y measuring and introducing into a mixer the ingredients for a batch of concrete. To produce a uniform quality concrete mix, measure the ingredients accurately for each batch. Most concrete specifications require that the batching be performed by weight, rathcr than by volume, because of inaccuracies in measuring aggregate, especially damp aggregate. Water and liquid air-entraining admixtures can be measured accurate]y by either weight or volume. Batching by using weight provides greater accuracy and avoids problems created by bulking of damp sand. Volumetric batching is used for concrete mixed in a continuous mixer, and the mobile concrete mixer (crete mobile) where weighing facilities are not at hand.

Specifications generally require that materials be measured in individual batches within the following percentages of accuracy: cement 1%, aggregate 2%, water 1%, and air-entraining admixtures 3%.

Equipment within the plant should be capable of measuring quantities within these tolerances for the smallest to the largest batch of concrete produced. The accuracy of the batching equipment must be checked and adjusted when neccessary.

Mixing Concrete

Concrete should be mixed until it is uniform in appearance and all the ingredients are evenly distributed. Mixers should not be loaded above their rated capacities and should be operated at approximately the speeds for which they were designed. If the blades of the mixer become worn or coated with hardened concrete, the mixing action will be less efficient. Worn blades should be replaced and the hardened concrete removed periodically, preferably after each production of concrete.

When a transit mixer (TM) (fig. 7-1) is used for mixing concrete, 70 to 100 revolutions of the drum at the rate of rotation designated by the manufacturer as *mixing speed* are usually required to produce the specified uniformity. No more than 100 revolutions at mixing speed should be used. All revolutions after 100 should be at a rate of rotation designated by the manufacturer as *agitating speed*. Agitating speed is usually about 2 to 6 revolutions per minute, and mixing speed is generally about 6 to 18 revolutions per minute. Mixing for long periods of time at high speeds, about 1 or more hours, can result in concrete strength loss, temperature rise, excessive loss of entrained air, and accelerated slump loss.

Concrete mixed in a transit mixer should be delivered and discharged within 1 1/2 hours or before the drum has revolved 300 times after the introduction of water to cement and aggregates or the cement to the aggregates. Mixers and agitators should always be operated within the limits of the volume and speed of rotation designated by the equipment manufacturer.

Overmixing Concrete

Overmixing concrete damages the quality of the concrete, tends to grind the aggregate into smaller pieces, increases the temperature of the mix, lowers the slump, decreases air entrainment, and decreases the strength of the concrete. Also, overmixing puts needless wear on the drum and blades of the transit mixer.

To select the best mixing speed for a load of concrete, estimate the travel time to the project (in minutes) and divide this into the minimum desired number of revolutions at mixing speed-70. The results will be the best drum speed; for instance, if the haul is 10 minutes, 70 divided by 10 equals 7. With this drum speed, the load will arrive on the jobsite with exactly 70 turns at mixing speed, with no overmixing of the concrete mix and no unnecessary wear on the

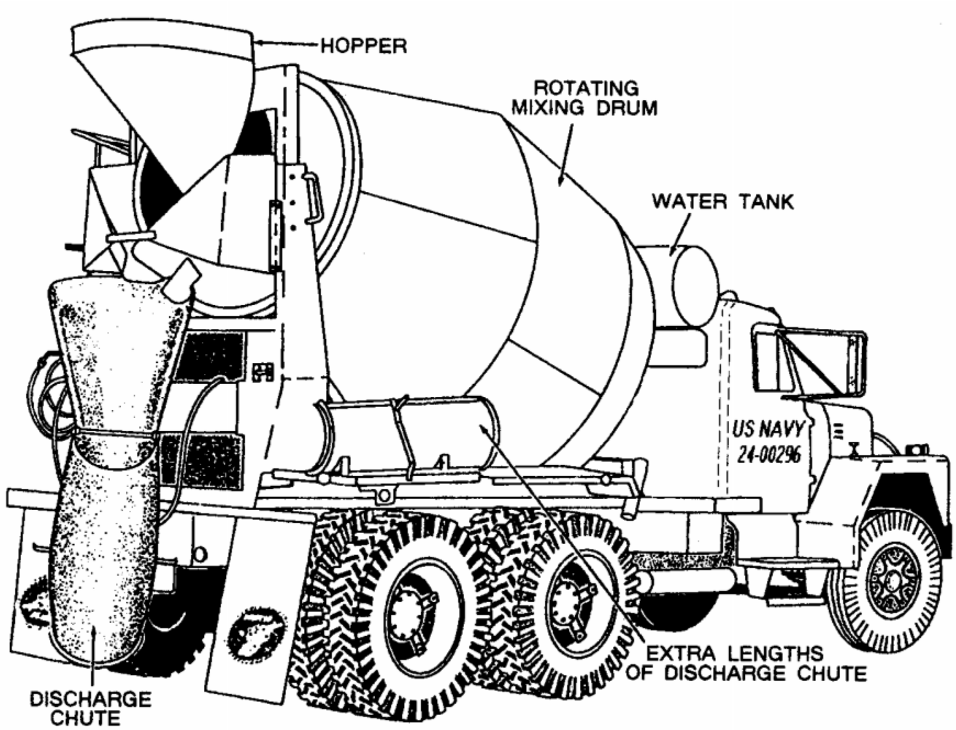

Figure 7-1.-Transit mixer.

equipment. If the concrete cannot be discharged immediately, the operator should turn the drum at the minimum agitating speed of 2 revolutions per minute. When the transit mixer arrives at the project having used the minimum amount of mixing turns, the operator is able, if necessary, to delay discharging the concrete. Delay is limited by the maximum of 300 rotations allowed.

Remixing Concrete

Concrete begins to stiffen as soon as the cement and water are mixed. However, the degree of stiffening that occurs in the first 30 minutes is not usually a problem; concrete that is kept agitated generally can be placed within 1 1/2 hours after mixing.

Fresh concrete left to agitate in the mixer drum may be used if upon remixing it becomes sufficiently plastic to be consolidated in the forms. Under careful **supervision** a small amount of water may be added to remix the concrete provided the following conditions are met: (1) maximum allowable water-cement ratio is not exceeded, (2) maximum allowable slump is not exceeded, (3) maximum allowable mixing and agitating time (or drum revolutions) are not exceeded, and (4) concrete is remixed for at least half the minimum required mixing time or number of revolutions.

Adding too much water to make concrete more fluid should not be allowed because this lowers the quality of the concrete. Remixed concrete can be expected to harden quickly. Subsequently, a cold joint may develop when concrete is placed next to or above the remixed concrete.

Mixer Cleaning

After the load of concrete is discharged from the mixer, the operator should wash off all excess concrete in the mixer drum and blades, the discharge chute opening, and the discharge chute before it has a chance to harden. Spraying 15 to 25 gallons of water into the drum while it is rotating will clean the inside of the drum as well as remove all grout which may have collected in the water nozzle during discharge. A washdown hose is provided on the mixer to clean areas accessible from the outside. A clean mixer produces a more satisfactory mixing and discharge of concrete.

At the plant, flush a minimum of 150 to 250 gallons of water, depending on the size of the mixer, into the drum. With the flush water in the drum, rotate the drum in the mixing direction for a few minutes, then discharge the flush water at the maximum drum rpm. Complete the cleaning of the outside of the mixer, particularly around the discharge end.

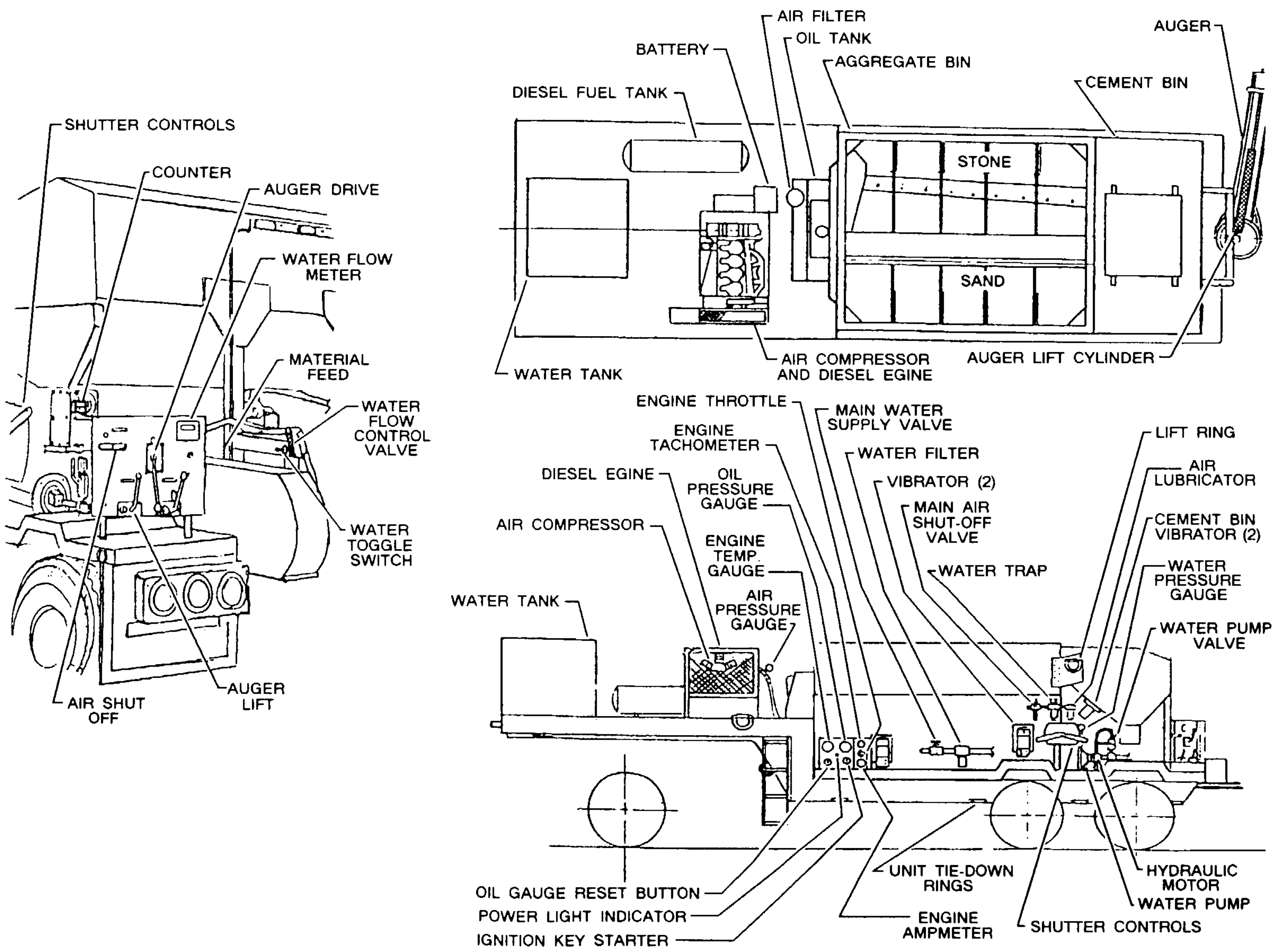

Figure 7-2.–Mobile concrete mixer plant.

MOBILE CONCRETE MIXER PLANT

The trailer-mounted mobile concrete mixer plant (fig. 7-2) carries cement, sand, and coarse aggregates in divided bins mounted on the unit. The cement is carried in a separate bin located across the rear of the unit, and the sand and aggregate are carried on each side of the unit. Water is carried in a single tank mounted in front of the aggregate bins and is pumped to the mix auger. Sand and aggregates are accurately proportioned by weight or volume and simultaniously dropped with a mixture of cement from the material feed system into the charging end of the mix auger/conveyor at the rear of the unit. At this point, a predetermined amount of water enters the mix auger. The action of this combined auger and paddle homogenizer mixes the ingredients and water rapidly, thoroughly, and continuously to produce a continuous flow of uniformed quality concrete. The material mixing action is a continuous process that can proceed until the aggregate bins are empty. On the other hand, mixing and delivery may be stopped at any time and then started again at the will of the operator. This permits production to be balanced to the demands of the placing and finishing crews and other job requirements.

Operators assigned to the “crete mobile” must thoroughly read and understand the technical manual before operating the plant.

The following are the mobile concrete mixer plant cautions and warnings:

Follow all preventivc maintenance procedures.

- Do not allow any foreign matter in the cement bin.
- Do not allow paricles larger than 1 1/2 inch in the aggregate bin.
- Do not allow the waterlines and flowmeters to freeze with water in them.
- Do not run the water pump dry.
- Do not continue to operate the machine if the hydraulic oil temperature exceeds 190°F.
- Wash out the auger within 20 minutes of the last use.
- Never attempt to operate the unit while in motion.
- Never attempt to repair the machine while in operation (always turn the power source off).
- Keep your entire body clear from all moving parts.
- Never attempt to walk on top of the aggregate bin to cross from the cement bin to the water tank (use the ladder).
- Never walk or stand under the auger.
- Never climb inside the aggregate bin (use a small pole to dislodge any aggregate that has bridged).
- Never enter the cement bin while in operation (there are moving parts inside the bin).

SLUMP TEST

The slump test is used to measure the consistency of a concrete mix. The test is normally performed by an Engineering Aid (EA) and is made by using a slump cone. The cone is 12 inches high with an 8-inch-diameter base and a 4-inch-diameter top (fig. 7-3).

A bucket is filled with a sample of the concrete from the discharge chute from the mixer. From this sample, the cone is filled in three layers. Each layer should contain approximately one third of the volume of the cone. Each layer is *rodded in* the cone with 25 strokes from a 5/8-inch-diameter tamping rod 24 inches long. The strokes should be distributed uniformly over the cross section of the cone and should penetrate into the underlying layer. The bottom layer should be rodded

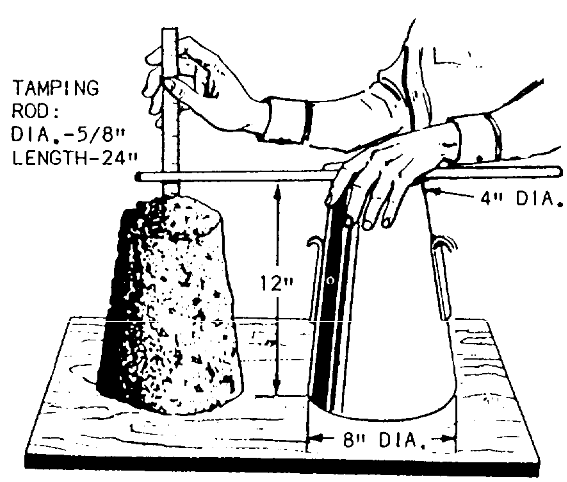

Figure 7-3.-Measurement of slumps.

throughout the depth. The strokes will eliminate any voids when the concrete is placed in the cone.

If the cone is overfilled, the excess concrete is made flush with the top of the cone with a straightedge. The cone is raised from the concrete by raising the cone carefully in a vertical direction. The slump is determined by measuring the difference between the height of the cone and the height of the concrete specimen (fig. 7-3). The slump is recorded in inches on the quality control report.

After the slump measurement is completed, the side of the mix is tapped gently with the tamping rod. The behavior of the concrete under this test is a valuable indication of the cohesiveness, workability, and placability of the concrete mix. If the mix is well-proportioned, tapping will only cause it to slump lower and retain its original identity, and a poor mix will crumble, segregate, and fall apart. Normally, the EAs perform three slump tests per truck load of concrete. Another test performed by the EAs on a concrete mix is a concrete strength test. This test is performed to control the quality of concrete manufactured in the field, to evaluate the performance of available materials used in a concrete mix, and to establish mix proportions that give concrete the required strength.

PLANT SAFETY

1. All personnel working in the batch plant area should wear hard hats at all times.
2. When hoppers are being charged with a clamshell or loader, personnel should stay away from the area of falling aggregate.
3. Housekeeping of the charging area is important. Keep the area clean and free of spoiled material and overflow.
4. Respirators must be worn by all personnel when handling bag or bulk cement.
5. Particular attention should be given to any rash or other irregularities of the skin as it might indicate “cement poisoning.”
6. Vapor type of goggles should be worn by personnel in batch plant operations.

TRANSIT MIXER SAFETY

The use of transit mixers on construction projects impose traffic problems that must be considered. Caution must be used during backing of the transit mixer. Backing should be controlled by a signalman, positioned so the operator can clearly observe the directions given. Extrement caution must be used when traveling on a construction site. The stability of the mixer is greatly reduced with the extra weight of the concrete. Also, the weight of the mixer can crush newly placed underground utilities, sink in the mud, crack sidewalks, and so forth. In such cases, a slow speed is recommended.

Some additional safety precautions that must be enforced are as follows:

1. Reduce speed before making a turn or applying the truck brakes.
2. Secure the discharge chute properly, using the lock provided.
3. Check to make certain other personnel are in the clear before starting the mixer charging or discharging.
4. Make sure the mixer is stopped before making any adjustments.